



IN REPLY REFER TO:

United States Department of the Interior

FISH AND WILDLIFE SERVICE

JUL 30 1997

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Sacramento Fish and Wildlife Office
3310 El Camino Avenue, Suite 130
Sacramento, California 95821-6340

July 28, 1997

Mr. Lester S. Snow
Executive Director
CALFED Bay-Delta Program
1416 Ninth Street, Suite 1155
Sacramento, California 95814

Subject: San Francisco Estuary Institutes's Category III Exotic Species Control
Proposals

Dear Mr. Snow:

The Sacramento Fish and Wildlife Service Office supports the eight proposals submitted by the San Francisco Estuary Institute for exotic species research and control in the Sacramento-San Joaquin Bay-Delta estuary. These eight projects fit within the recommended actions in the Delta Native Fishes Recovery Plan and will help recover listed species in the estuary.

The Service recommends funding of these projects. Such projects are consistent with our mission of preserving fish and wildlife and recovering natural ecosystems and watersheds.

If you have any questions or concerns about the above, contact Robert Pine at (916) 979-2725.

Sincerely,

Wayne S. White
Field Supervisor

CC: San Francisco Estuary Institute, Richmond, California

- a. Project Title:** Review and Assessment of the Status, Risk and Management Needs Regarding the Introduction of Nonindigenous Species via Aquaculture Activities. **DWR WAGNERHOUSE**

Applicant's Name: The San Francisco Estuary Institute.

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Principal Investigator: Dr. Andrew Cohen

- b. Project Description and Objectives:** The goals of this project are to understand the status and trends of aquaculture-associated introductions in California waters, assess the risk of additional introductions, develop procedures and management approaches to prevent new introductions, and reduce the impacts and spread of existing introductions.
- c. Approach/Tasks/Schedule.** This project will involve review of published literature, government reports and data, codes of law and regulation, and interviews with aquaculturists and researchers and agency personnel that deal with aquaculture. It will
- compile a profile of the aquaculture industry, including cultured species, locations of facilities, sources of seed stock, export markets, and trends in species cultured;
 - assemble information on diseases, pathogens, and parasites reported from California facilities;
 - identify practices or conditions in aquaculture that may allow the transport of nonindigenous organisms into the State and between facilities;
 - identify practices or conditions in aquaculture that may allow the release of nonindigenous organisms into the environment during transport, while in facilities, or via marketing;
 - gather information on the status and impacts of aquaculture-associated introductions in the environment;
 - gather information on the legal and regulatory structure, and on the efficacy of implementation and enforcement practices, aimed at reducing the risks of aquaculture-associated introductions.

Based on this information, the project will evaluate the level of risk for imports and unintentional releases to occur, prioritize areas and practices of greatest risk; and recommend changes in industry practices and/or regulatory structure to reduce these risks.

A final report will be completed within one year of the date that funds are made available.

- d. Justification for Project Funding by CALFED.** The San Francisco Bay Estuary is recognized as the most invaded aquatic ecosystem in North America, with more than 200 introduced invertebrates, fish, plants, and microorganisms. The introduction of nonindigenous species has been identified as a critical factor affecting the health of the Bay/Delta Estuary by water agencies, environmental groups, the CCMP, BCDC, USFWS, CALFED and others. It is one of the seven non-flow factors targeted for research and management by Category III funding, and is one of the main stressors listed by the technical teams as appropriate for near-term funding and priorities. Nonindigenous species may in general affect and have affected all of the priority habitats listed in this RFP. Researchers have also demonstrated or suggested that nonindigenous species have caused significant negative impacts on several priority species (salmon, trout, Delta smelt, sturgeon).

Aquaculture is one of the main mechanisms operating today transporting aquatic organisms around the world, transferring organisms across oceans and continents and within regions. In addition to cultured fish and shellfish species and their food, substrate and packing material, other organisms living in, on or among these are sometimes inadvertently transported along with them. These organisms frequently include pests, parasites or diseases of the cultured and commercially important species. Aquaculture-introduced species have had significant impacts on commercial fisheries and natural communities in inland, estuarine, and marine waters in California. They pose a growing threat to fisheries, natural communities, and special status species, as the geographic distribution and scale of aquaculture operations increase.

- e. **Budget Costs and Third Party Impacts.** The total cost of this project is \$28,907. No third party impacts are anticipated.
- f. **Applicant Qualifications.** The San Francisco Estuary Institute (SFEI) is a 501(c)(3) non-profit research institute created in 1994. SFEI is charged with fostering scientific understanding of the Estuary, and with promoting the implementation of a comprehensive, coordinated *Regional Monitoring and Research Strategy* that addresses the physical, biological and chemical health of the Estuary. The creation of SFEI responds to a recommendation of the Comprehensive Conservation and Management Plan (CCMP) for the San Francisco Estuary adopted by the Governor of California and the Administrator of the U.S. Environmental Protection Agency in late 1993. The Institute has a staff of 22 headed by an Executive Director, and comprised of an interdisciplinary team of scientists, education specialists, data analysts, and support personnel. The Institute also employs graduate students and undergraduate interns from area Universities. The Institute conducts or provides science support for four major programs: The San Francisco Estuary Regional Monitoring Program for Trace Substances, the Bay Area Wetlands Ecosystem Goals Project, the Bay Area Watershed Science Program, and the Biological Invasions Program.

SFEI's Biological Invasions Program researches issues of scientific and policy interest related to the introduction of nonindigenous species into marine and freshwater ecosystems. The research program is directed toward five objectives: (1) assisting efforts to prevent future invasions through scientific and policy research on vectors and the control of vectors; (2) developing an effective regional monitoring program to identify new invasions and track the spread of nonindigenous species that are present in the region; (3) understanding how factors in the environment affect the success of invasions; (4) assessing the impacts of invasions; (5) prioritizing and assessing efforts to control nonindigenous species that are present in the region.

Principal Investigator, Dr. Andrew Cohen received M. S. and Ph. D. degrees in Energy and Resources from the University of California at Berkeley. He is the author of a 1995 USFWS report on nonindigenous species in the San Francisco Estuary and of papers on other aspects of marine and aquatic invasions. Dr. Cohen has also worked on and written about water system planning and economics, public health and contaminants in fish, and environmental mitigation; and has written articles and books for the general public on water and environmental policy and history. His work on invasions in the Estuary was profiled last year in the *New York Times* Science Page, and he was recently nominated to co-chair the Western Regional Panel on Aquatic Nuisance Species. He currently directs the San Francisco Estuary Institute's research program on biological invasions.

- g. **Monitoring and Data Evaluation.** The draft report will be circulated for comment to the aquaculture industry, regulatory agencies and other stakeholders. In addition, any persons recommended by CALFED will be asked to review the report.
- h. **Local Support/Coordination with other programs/Compatibility with CALFED objectives.** All habitats and species included as priorities in the Ecosystem Restoration Program Plan could be directly or indirectly affected by the establishment of new exotic species, and thus stand to benefit from this project. In addition, the information gathered in this report will be of direct value to aquaculture operations throughout California. Aquaculturists, aquaculture researchers, and agency personnel that deal with aquaculture will be consulted in the course of this project.

Review and Assessment of the Status, Risk and
Management Needs Regarding the Introduction of
Nonindigenous Species via Aquaculture Activities

Principal Investigator: Andrew N. Cohen
San Francisco Estuary Institute
1325 South 46th Street
Richmond, CA 94804
phone: (510) 231-9423
fax: (510) 231-9414
email: acohen@sfei.org

Organization Type: Nonprofit research institute
503(c)(3) nonprofit organization

Tax identification number: 94-2951373

Contact person: Andrew Cohen

Participants/Collaborators: Anna Weinstein

Project Group Type: Services

Introduction: Biological Invasions in the Estuary

The San Francisco Bay Estuary is recognized as the most invaded aquatic ecosystem in North America, with more than 200 introduced invertebrates, fish, plants, and microorganisms. The introduction of nonindigenous species has been identified as a critical factor affecting the health of the Bay/Delta Estuary by water agencies, environmental groups, the CCMP, BCDC, USFWS, CALFED and others. It is one of the seven non-flow factors targeted for research and management by Category III funding, and is one of the main stressors listed by the technical teams as appropriate for near-term funding and priorities. Nonindigenous species may in general affect and have affected all of the priority habitats listed in this RFP. Researchers have also demonstrated or suggested that nonindigenous species have caused significant negative impacts on several priority species (salmon, trout, Delta smelt, sturgeon).

The San Francisco Estuary Institute has initiated a research program to address issues of scientific and policy interest related to the introduction of nonindigenous species into marine and freshwater ecosystems. The research program is directed toward five objectives: (1) assisting efforts to prevent future invasions through scientific and policy research on vectors and the control of vectors; (2) developing an effective regional monitoring program to identify new invasions and track the spread of nonindigenous species that are present in the region; (3) understanding how factors in the environment affect the success of invasions; (4) assessing the impacts of invasions; (5) prioritizing and assessing efforts to control nonindigenous species that are present in the region. Proposals in several of these areas are being submitted in the current funding cycle.

Project Description and Approach

Aquaculture is one of the main mechanisms operating today transporting aquatic organisms around the world, transferring organisms across oceans and continents and within regions. In addition to cultured fish and shellfish species and their food, substrate and packing material, other organisms living in, on or among these are sometimes inadvertently transported along with them. These organisms frequently include pests, parasites or diseases of the cultured and commercially important species.

Aquaculture- introduced species have had significant impacts on commercial fisheries and natural communities in inland, estuarine, and marine waters in California. They pose a growing threat to fisheries, natural communities, and special status species, as the geographic distribution and scale of aquaculture operations increase. The goals of this project are to understand the status and trends of aquaculture-associated introductions in California waters, assess the risk of additional introductions, develop procedures and management approaches to prevent new introductions, and reduce the impacts and spread of existing introductions. Specifically, the project will:

- 1) Assemble data on the existing aquaculture activities in California. This will include data on activities that may transport nonindigenous species into the state and transfer them between regions, and on activities or conditions that may release or allow the escape of these organisms into the environment.
- 2) Assemble information on the existing monitoring and regulatory programs that act to reduce the risk of introducing nonindigenous species into the state and of releasing them into the environment.
- 3) Evaluate the risks that exist for such imports and releases to occur.
- 4) Describe approaches to minimize these risks.

Location/Geographic Boundaries

Organisms that are introduced by aquaculture activities into California waters that are outside of the San Francisco Bay/Delta watershed may nevertheless spread into the watershed either by natural or human-associated transport mechanisms. Also, most regulation of aquaculture is done at the state level. Therefore, the scope of this study will include all aquaculture activities within the state.

Expected Benefits

1) Benefits to fresh, estuarine, and marine natural communities

Improvements in preventing the accidental import release of exotic species via aquaculture would benefit species and natural communities by preventing the introduction of new species. Aquaculture-associated introduced exotics create impacts—competition, predation, and disease—that can hurt some species, including special status species, and change community structure. All habitats and species included as priorities under CALFED could be directly or indirectly affected by the establishment of new exotic species, and thus stand to benefit from this project.

2) Benefits to commercial and recreational fisheries

Similarly, commercial and recreational fisheries would benefit from accidental introductions via aquaculture. Pests, predators, parasites and diseases of the cultured organisms are among the accidentally imported organisms in aquaculture, and in many cases commercial and sport fisheries are based on species that are closely related to or the same as those cultured by aquaculture and which therefore may serve as hosts or prey to these harmful exotics.

3) Benefits to aquaculture operations

Benefits to aquaculture operations are of three types:

- a) The report will provide information on the mechanisms by which pests, predators, parasites and diseases may be imported into California and spread

among facilities, and on procedures for controlling these risks. Such information should be of direct value to aquaculture operations.

- b) The report will provide information on mechanisms by which organisms may be escaping from aquaculture operations into the environment, and on procedures for controlling these risks. Pest, predator, parasite or disease organisms established in the environment may contaminate wild sources of brood stock or food harvested for aquaculture operations, leading to reinfection of aquaculture facilities.

4) Benefits to regulatory agencies

The above benefits would all be of interest to resource agencies. The report will serve as a guide for allocating scarce agency resources for dealing with aquaculture-related introductions. It will consolidate and interpret existing conditions, increasing the general level of understanding of the status and trends of aquaculture activities that may lead to introductions. It will enhance the visibility of the issue in the public eye, leveraging agency power to develop and enforce effective, cost-efficient regulations that reduce the risk of introductions. Fewer future introductions could save the resource agencies money; while losses to industry do not directly impact resource agencies, the addition of staff or allocation of resources to control the impacts of introduced species would increase costs.

Background and Biological/Technical Justification

Aquaculture is recognized as an important vector of exotic species introduction in natural communities around the world. Most aquaculture facilities are imperfectly isolated from the environment, and many releases or escapes of nonindigenous species have occurred from such facilities, in California and around the world. Impacts reported in receiving waters include the outbreak of disease in commercial and wild species, and introduction of other exotic species that compete with or prey on native species (Carlton 1996). Continued growth in aquaculture activities worldwide threaten to increase the rate and scope of introductions (Norse 1993).

The fresh and estuarine waters of the Bay Delta and its watershed support significant commercial and sport fisheries and shellfisheries, which could be damaged by pathogens and parasites introduced by aquaculture. For example, in many parts of the United States, wild and cultured stocks of salmon and trout have been damaged by whirling disease, an exotic protozoan parasite transmitted by stocked trout and frozen fish used for feed. In Norway, an exotic, aquaculture-introduced trematode eliminated native salmon runs on several rivers (Mo 1994).

Other examples of aquaculture-associated introduced species impacts include the outbreak of Malpeque Bay Disease in commercial oysters in beds around Prince Edward Island, British Columbia; Bonamia disease in Washington and Maine; and, the introduction of the fouling gastropod *Crepidula fornicata* to Great Britain through imports of *Crassostrea virginica* from the eastern United States. Such

diseases have hurt shellfishing economies. Examples of direct competition of mariculture species with native species include the displacement of native oysters by the Japanese oyster *C. gigas* in Australia, where *C. gigas* is now officially listed as a pest species.

California's unique aquatic ecology and burgeoning aquaculture industry make many of its waters highly vulnerable to aquaculture-associated introductions. This project will provide the aquaculture industry and resource managers with the information needed to take effective and cost-efficient steps to reduce the risks of further introductions from aquaculture.

Proposed Scope of Work

We will review published literature, government reports and data, and codes of law and regulation, and interview aquaculturists and researchers and agency personnel that deal with aquaculture, in order to:

- a) compile a profile of the aquaculture industry, including cultured species, locations of facilities, sources of seed stock, export markets, and trends in species cultured;
- b) assemble information on diseases, pathogens, and parasites reported from California facilities;
- c) identify practices or conditions in aquaculture that may allow the transport of nonindigenous organisms into the State and between facilities;
- d) identify practices or conditions in aquaculture that may allow the release of nonindigenous organisms into the environment during transport, while in facilities, or via marketing;
- e) gather information on the status and impacts of aquaculture-associated introductions in the environment;
- f) gather information on the legal and regulatory structure, and on the efficacy of implementation and enforcement practices, aimed at reducing the risks of aquaculture-associated introductions;

Based on this information we will evaluate the level of risk for imports and unintentional releases to occur, and prioritize areas and practices of greatest risk; and will recommend changes in industry practices and/or regulatory structure to reduce these risks.

We will then produce a report containing the above information, assessments and recommendations. The report will be circulated for comment to the aquaculture

industry, regulatory agencies and other stakeholders, before revisions and submission of a final version to CALFED.

The final report will be the deliverable from this project.

Monitoring and Data Evaluation

As noted above, the draft report will be circulated for comment to the aquaculture industry, regulatory agencies and other stakeholders. In addition, any persons recommended by CALFED will be asked to review the report.

Implementability

There are no anticipated implementation issues. The project involves no specimen collecting or property use issues, and no permits will be required.

References

1. Mo, T. A. 1994. Status of *Gyrodactylus salaris* problems and research in Norway. In: *Parasitic Diseases of Fish*, A.W. Pike and J.W. Lewis, eds. Samara Publishing Limited, London.
2. Barber, B. J. 1996. Impacts of shellfish introductions on local communities (abs). Proceedings of Workshop: Exotic species: issues relating to aquaculture and biodiversity.
3. Carlton, J. 1996. Issues related to exotic species introductions and biodiversity. (abs). Proceedings of the Workshop: Exotic species: issues relating to aquaculture and biodiversity.
4. Norse, E. 1993. *Global Marine Biodiversity*. Island Press, New York.
5. Great Lakes Science Panel. 1996. *Biological Invasions* (pamphlet).

Budget Costs

Project Tasks	Direct Labor Hours	Direct Salary and Benefits	Overhead Labor	Other Direct Costs	Total Cost
Research					
Andrew Cohen	80	4668.00	2427.36		
Anna Weinstein	320	5353.60	2783.87		
travel				1100.00	
miscellaneous costs				300.00	16532.83
Report Production					
Andrew Cohen	80	4668.00	2427.36		
Anna Weinstein	200	2676.80	1391.94		
production costs				300.00	11564.10
TOTAL		17366.40	9030.53	1700.00	28096.93

Budget ExplanationResearch - Travel

2500 mi @ \$0.30/mi = \$750

Per diems: 10 days @ \$35/day = \$350

TOTAL = \$1100

Research - Miscellaneous Costs

Books, reports, copyinfgr estimated at \$300

Report - Production Costs

Copying, printing, graphics estimated at \$300

Schedule

The start date of the project will depend on when a contract is executed and funds become available.

To complete:

elapsed time
from start date:

Research	6 mo.	6 mo.
Draft Report	2 mo.	8 mo.
Review	2 mo.	10 mo.
Final report	2 mo.	12 mo.

1. Organization description

The San Francisco Estuary Institute (SFEI) is a 501(c)(3) non-profit created in 1994. SFEI is charged with fostering scientific understanding of the Estuary, and with promoting the implementation of a comprehensive, coordinated *Regional Monitoring and Research Strategy* that addresses the physical, biological and chemical health of the Estuary. The creation of SFEI responds to a recommendation of the Comprehensive Conservation and Management Plan (CCMP) for the San Francisco Estuary adopted by the Governor of California and the Administrator of the U.S. Environmental Protection Agency in late 1993.

The Institute has a staff of 22 headed by an Executive Director, and comprised of an interdisciplinary team of scientists, education specialists, data analysts, and support personnel. The Institute also employs graduate students and undergraduate interns from area Universities. The Institute conducts or provides science support for four major programs: The San Francisco Estuary Regional Monitoring Program for Trace Substances, the Bay Area Wetlands Ecosystem Goals Project, the Bay Area Watershed Science Program, and the Biological Invasions Program.

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- Developing methods for prioritizing efforts to control exotic marsh plants in the Estuary.
- Assessing the potential range and abundance of zebra mussels in California waters.
- Research on the introduction of organisms in the marine baitworm trade.
- Research on the invasion of the California coast by a Japanese foraminifer.
- Developing a regional monitoring plan for exotic organisms.
- Modelling the effect of invasion "incubators" on the success of obligate sexually-reproducing invaders.
- Review of open coast invasions, with a case study of the invasion of the Southern California Bight by a New Zealand sea slug.
- Reviewing the effect of fragmentation and interconnection of river systems on the spread of nonindigenous species.

2. Project Staff

Andrew N. Cohen

Will manage the project, provide technical guidance where needed, oversee and participate in writing the report, and coordinate peer review.

Dr. Cohen received M. S. and Ph. D. degrees in Energy and Resources from the University of California at Berkeley. He is the author of a 1995 USFWS report on nonindigenous species in the San Francisco Estuary and of papers on other aspects of marine and aquatic invasions. Dr. Cohen has also worked on and written about water system planning and economics, public health and contaminants in fish, and environmental mitigation; and has written articles and books for the general public on water and environmental policy and history. His work on invasions in the Estuary was profiled last year in the *New York Times* Science Page, and he was recently nominated to co-chair the Western Regional Panel on Aquatic Nuisance Species. He currently directs the San Francisco Estuary Institute's research program on biological invasions.

Recent Publications

Carlton, J. T. and A. N. Cohen. Episodic global dispersal in shallow water marine organisms: The case history of the European green crab *Carcinus maenas*, *J. Biogeogr.* (in press).

Cohen, A. N. The exotic species threat to California's coastal resources, *Proc. California and the World Ocean '97 Conference*, March 24-27, 1997, San Diego CA (in press).

Cohen, A. N. The invasion of the estuaries. *Proc. 2nd International Spartina Conf.*, Mar. 20-22, 1997, Olympia WA (in press).

Carlton, J. T. and A. N. Cohen. Periwinkle's progress: The Atlantic snail *Littorina saxatilis* establishes a colony on Pacific shores, *Veliger* (in press).

Cohen, A. N. and J. T. Carlton. Transoceanic transport mechanisms: The introduction of the Chinese mitten crab *Eriocheir sinensis* to California, *Pac. Sci.* 51(1): 1-11, 1997.

Cohen, A. N. Biological invasions of the San Francisco Bay and Delta, *Proc. Nat'l Forum on Nonindigenous Species Invasions in U. S. Marine and Fresh Waters*, U. S. Capitol Building, Washington DC, Mar. 22, 1996.

Cohen, A. N. and J. T. Carlton. *Nonindigenous Aquatic Species in a United States Estuary: A Case Study of the Biological Invasions of the San Francisco Bay and Delta*. U. S. Fish and Wildlife Service, Washington DC, Dec. 1995.

Cohen, A. N., J. T. Carlton and M. C. Fountain. Introduction, dispersal and potential impacts of the green crab *Carcinus maenas* in San Francisco Bay, California, *Mar. Biol.* 122: 225-237, 1995.

Expert Testimony

San Francisco Bay Regional Water Quality Control Board, Jan. 22 1997: Biological invasions.

California State Water Resources Control Board, Oct. 5, 1994: Biological invasions.

California State Water Resources Control Board, Nov. 13 & 16, 1991: Water system management.

U. S. Senate, Committee on Energy and Natural Resources, Subcommittee on Water and Power, Mar. 18, 1991: Water system management.

Anna Weinstein

Will conduct the research and participate in writing the report.

Anna Weinstein received an M.S. in marine science from the Boston University Marine Program in Woods Hole, MA. She has for the past 8 years worked in conservation biology, environmental policy analysis, and proposal writing for a variety of public and private groups in the San Francisco and Monterey Bay areas. She led procedural review and formal comment for these groups on a variety of environmental issues, designed field surveys for ecological assessments, and published numerous lay articles on topics in biology and policy. She was the principal grants writer for the Watershed Ecology Group of California State University Monterey Bay, raising over \$400,000. She currently works on exotic species ecology and management at the San Francisco Estuary Institute, and on program development and grant proposal writing for the Island Conservation and Ecology Group at U. C. Santa Cruz.

NONDISCRIMINATION COMPLIANCE STATEMENT

COMPANY NAME

SAN FRANCISCO ESTUARY INSTITUTE

The company named above (hereinafter referred to as "prospective contractor") hereby certifies, unless specifically exempted, compliance with Government Code Section 12990 (a-f) and California Code of Regulations, Title 2, Division 4, Chapter 5 in matters relating to reporting requirements and the development, implementation and maintenance of a Nondiscrimination Program. Prospective contractor agrees not to unlawfully discriminate, harass or allow harassment against any employee or applicant for employment because of sex, race, color, ancestry, religious creed, national origin, disability (including HIV and AIDS), medical condition (cancer), age, marital status, denial of family and medical care leave and denial of pregnancy disability leave.

CERTIFICATION

I, the official named below, hereby swear that I am duly authorized to legally bind the prospective contractor to the above described certification. I am fully aware that this certification, executed on the date and in the county below, is made under penalty of perjury under the laws of the State of California.

OFFICIAL'S NAME

Margaret R. Johnston

DATE EXECUTED

July 25, 1997

EXECUTED IN THE COUNTY OF

Contra Costa County

PROSPECTIVE CONTRACTOR'S SIGNATURE

PROSPECTIVE CONTRACTOR'S TITLE

Executive Director

PROSPECTIVE CONTRACTOR'S LEGAL BUSINESS NAME

San Francisco Estuary Institute